Heat Transport into and out of measuring cells

dimensions :
sides: 50×10 = 500
ends: 10×8 =   80
top: 50×8 = 400

$$Q = \kappa \ \Sigma_i(A/d) \ \Delta T$$

acrylic
κ = .00033 $T^{-1.81}$ W/(cm K)
at 0.45 K, κ = 8 × 10^{-5} W/(cm K);
for 4 mW into single cell, full area, 1 cm wall
$\Sigma_i(A/d) \approx$ 2000 cm; ΔT = 25 mK

restricting surface area will result in a problem for heat flush
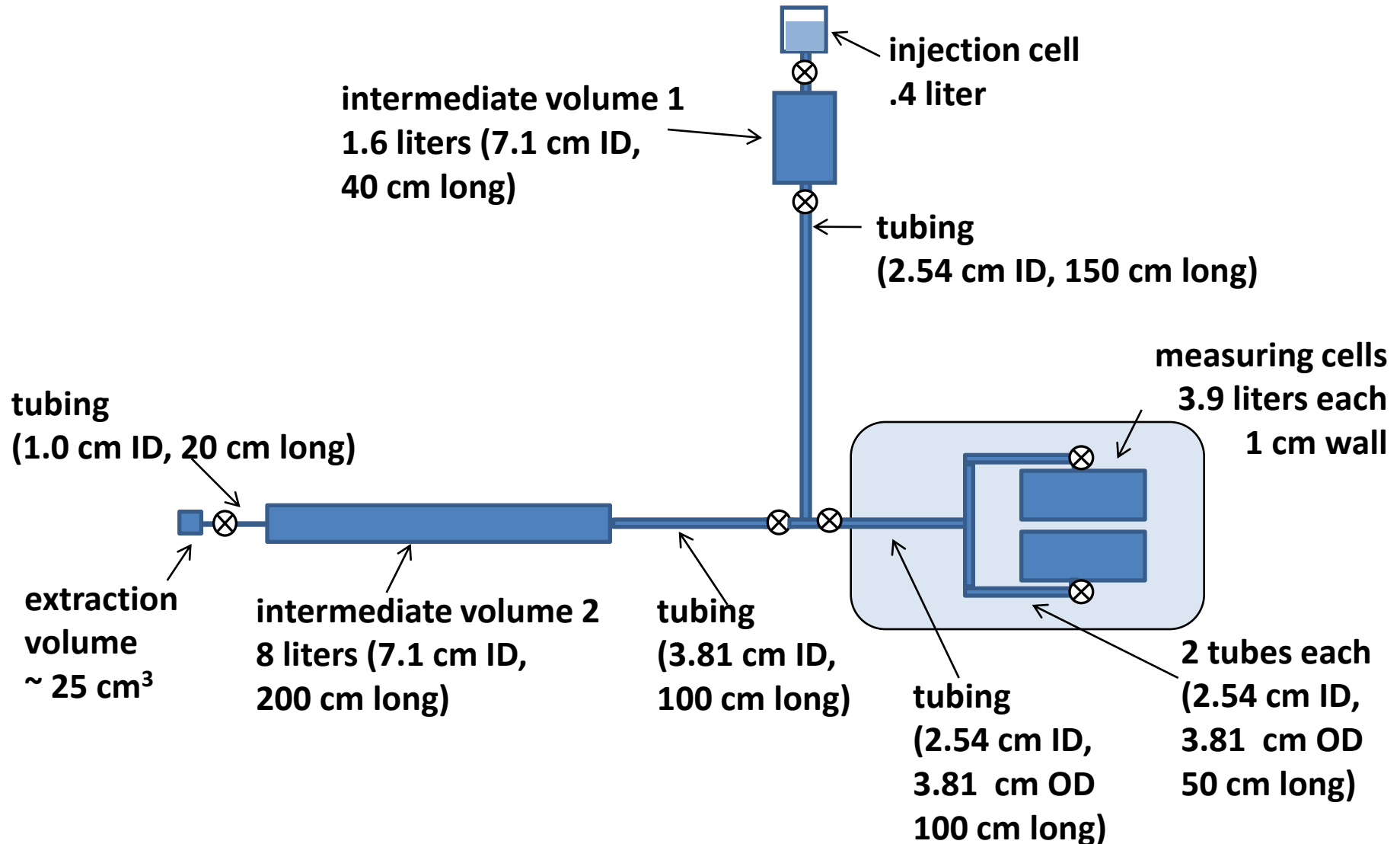
time constant
$\tau = (C/\kappa)(V/\Sigma_i(A/d))$
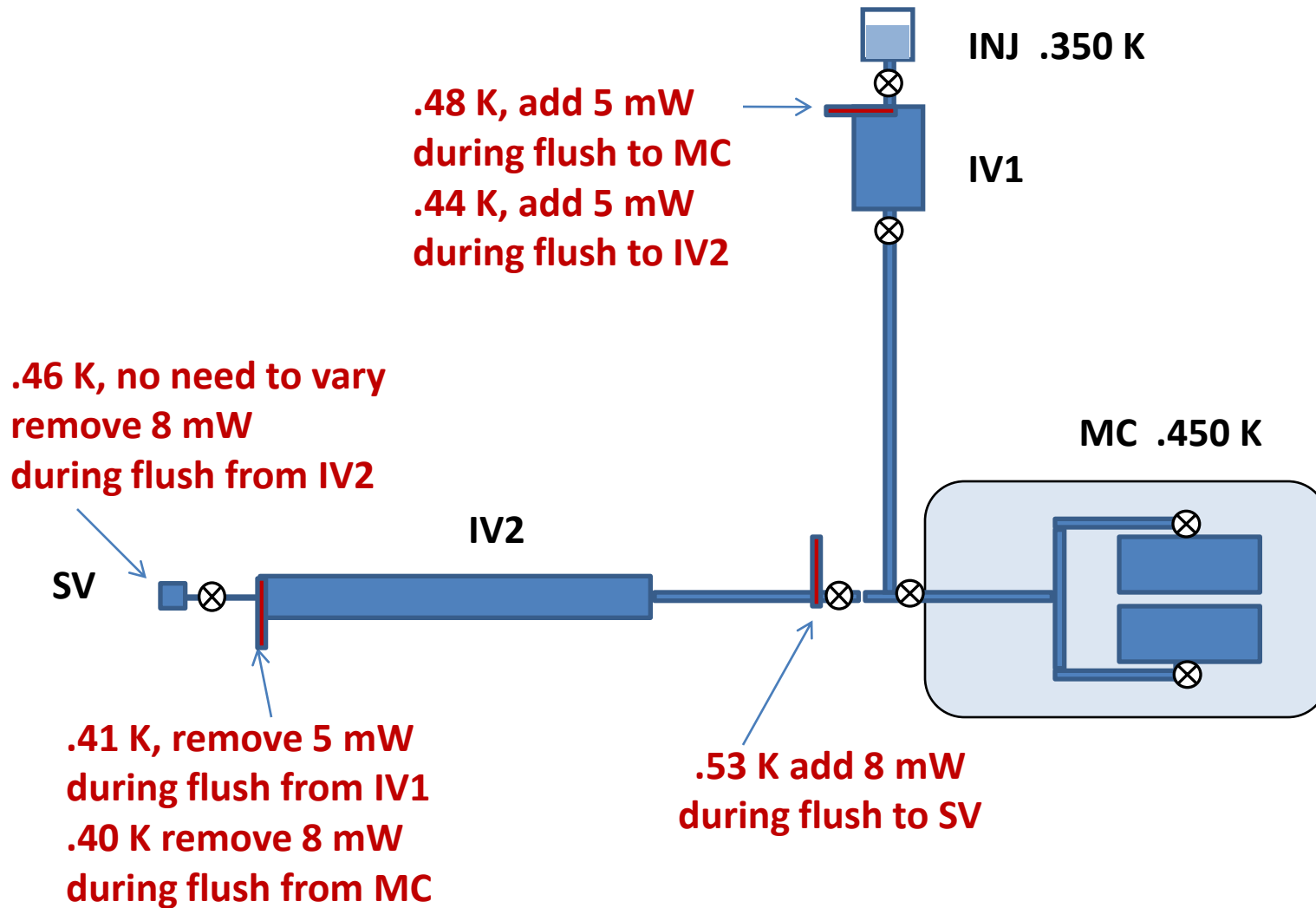at 0.45 K, C = 2.4 × 10^{-4} J/(K cm^3)
with V = 4000 cm^3
τ = 6 seconds

schematic of ³He transport system components and sizes

injection cell
.4 liter

intermediate volume 1
1.6 liters (7.1 cm ID,
40 cm long)

tubing
(2.54 cm ID, 150 cm long)

measuring cells
3.9 liters each
1 cm wall

tubing
(1.0 cm ID, 20 cm long)

extraction
volume
~ 25 cm³

intermediate volume 2
8 liters (7.1 cm ID,
200 cm long)

tubing
(3.81 cm ID,
100 cm long)

tubing
(2.54 cm ID,
3.81 cm OD
100 cm long)

2 tubes each
(2.54 cm ID,
3.81 cm OD
50 cm long)

schematic of ³He transport system temperatures and heat transfers

INJ .350 K

.48 K, add 5 mW
during flush to MC
.44 K, add 5 mW
during flush to IV2

IV1

MC .450 K

.46 K, no need to vary
remove 8 mW
during flush from IV2

IV2

SV

.41 K, remove 5 mW
during flush from IV1
.40 K remove 8 mW
during flush from MC

.53 K add 8 mW
during flush to SV

Seidel   5/08
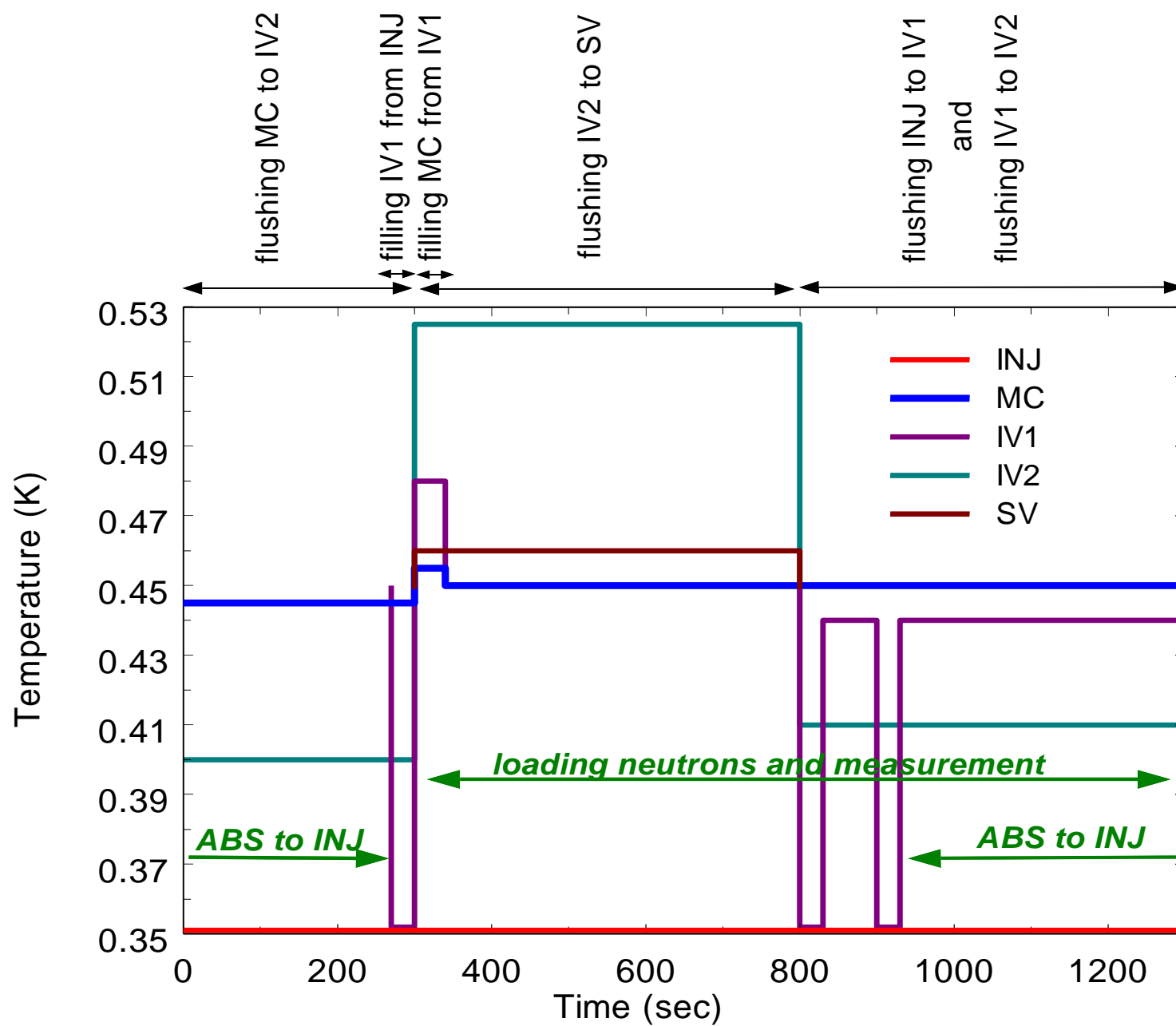
diffusion from injection cell to IV1

T = 0.35 K

INJ - 0.4 liters
IV1 - 1.6 liters
connected by
10 cm of
2.54 cm ID tubing

fraction of ^{3}He not in IV1

fraction of ^{3}He not in IV1 and
5 cm of tubing

fraction of ^{3}He in INJ
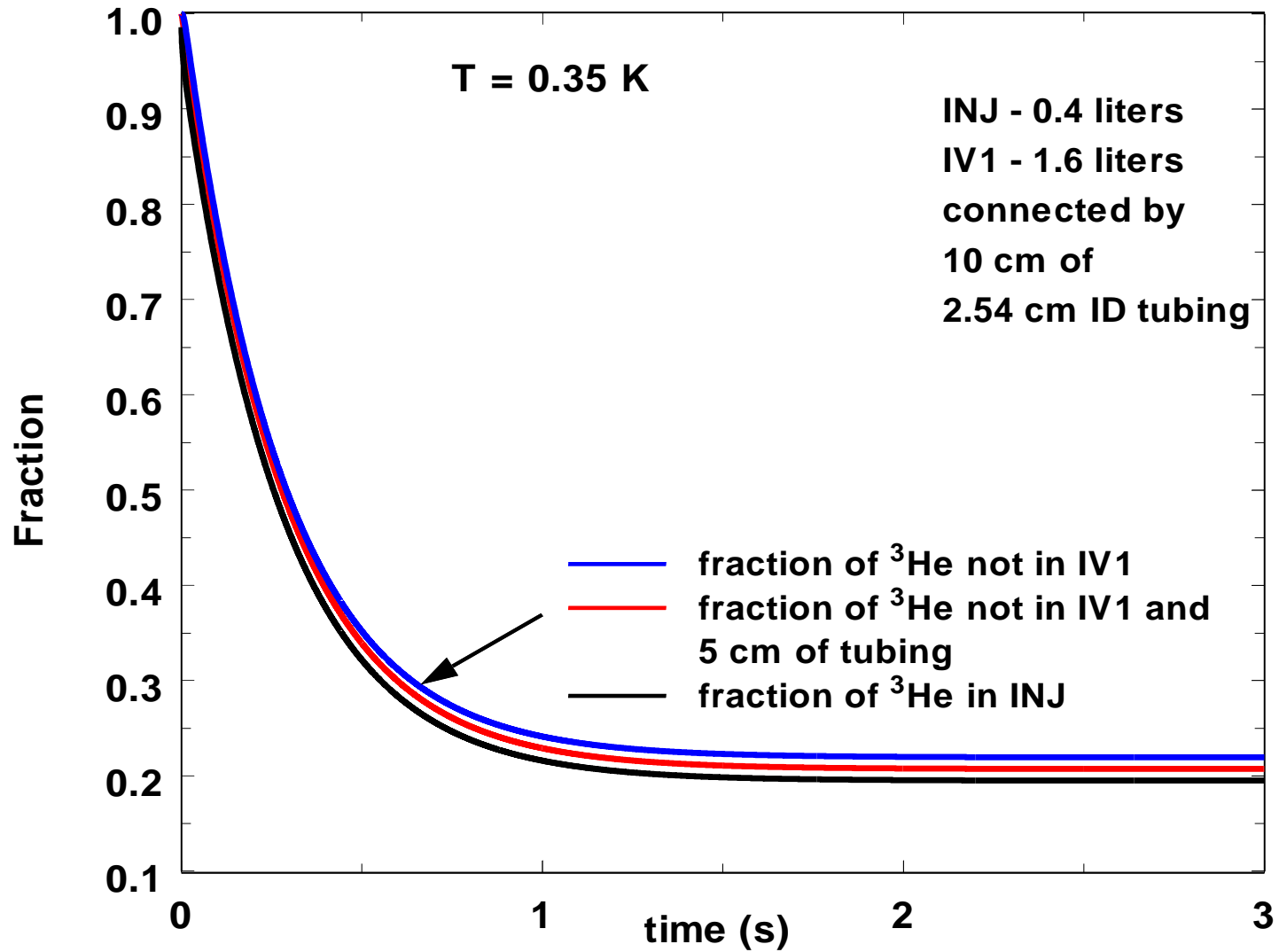
Fraction of ^{3}He in various components: Heat flush from IV1 to Mcell

- .... in IV1
- —— not in Mcell
- —·— in tubing

IV1 1.6 liters; tubing 2.6 cm ID
in vacuum: 150 cm
in liquid: 100 cm connected to
two of 50 cm

Fraction

Time (s)
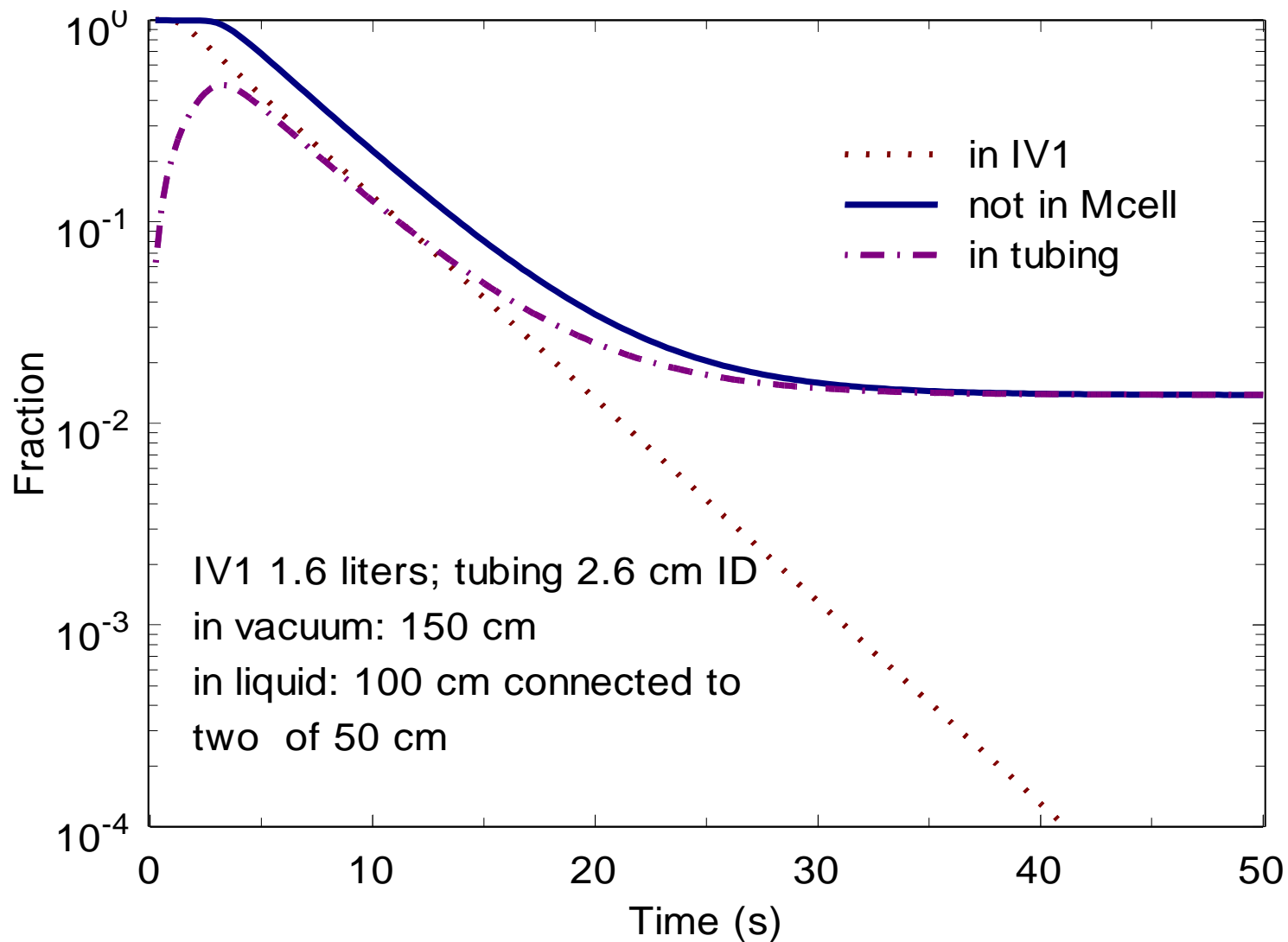
flushing ^{3}He from IV1 (1.6 LIt) into IV2 (8lit)

T=0.44K, 5 mW

tubing in series:
40 cm of 7.14 cm ID
150 cm of 2.54 cm ID
100 cm of 3.8 cm ID
200 cm of 7.14 cm ID
hot end held at .44 K
5 mW extracted
from cold end

fraction of ^{3}He not in IV1
fraction of ^{3}He not in IV1 and
150 cm of 2.54 cm ID tube

Seidel   5/08
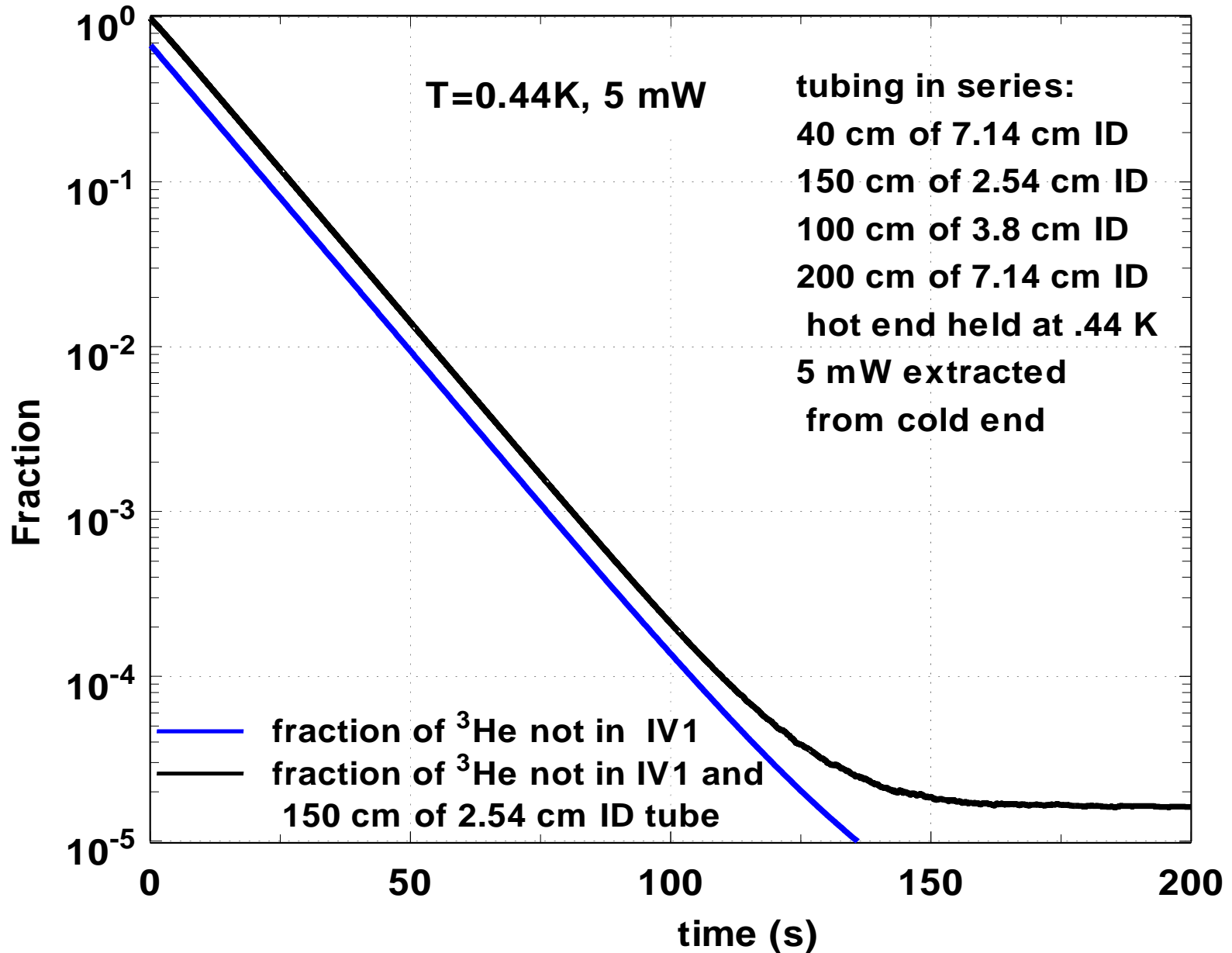
T=0.45K; 8.0 mW   measuring cells 7.75 liters

in helium:
tube 2.54 cm ID,
.64 cm wall, 100 cm
long, joining two
similar 50 cm long
tubes from cells

in vacuum:
tube 7.14 cm ID
200 cm long plus
100 cm of 3.8 cm
ID tubing

Concentration

time (s)

- - - concentration in measuring cells
—— fraction of ^{3}He remaining in cells and tubing in liquid

Seidel   5/08
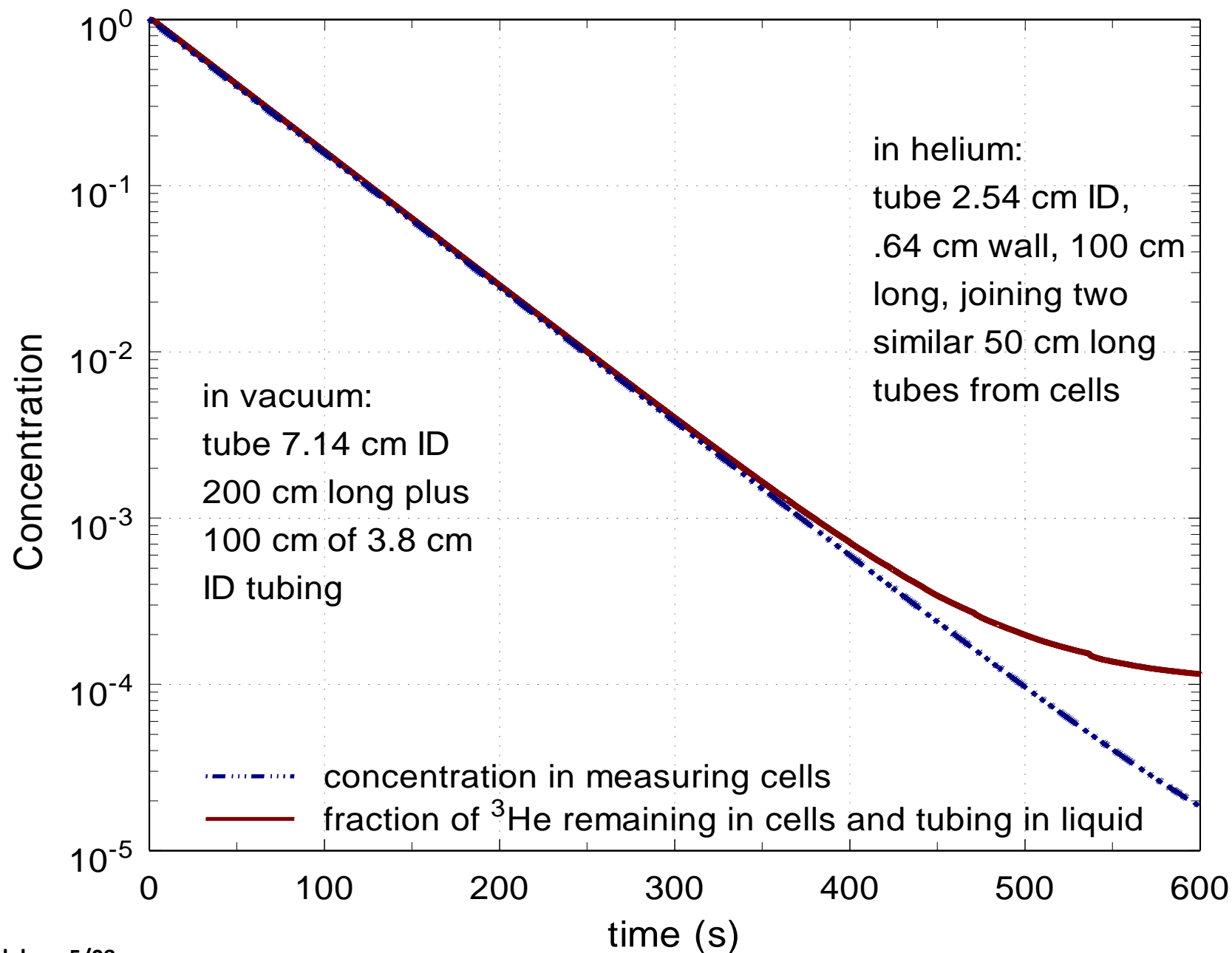
concentrating ^{3}He from 8 liter volume into ~25 cm^3

T=0.525K, 8 mW

tubing in series:
3 cm of 2.8 cm ID
20 cm of 1.0 cm ID
200 cm of 7.14 cm ID
100 cm of 3.81 cm ID
hot end held at .549 K
8 mW extracted
from cold end

fraction of ^{3}He not in 3 cm of 2.8 cm ID tube
fraction of ^{3}He not in 2.8 cm ID and
first 10 cm of 1 cm ID tube

Fraction

time (s)

Seidel   5/08
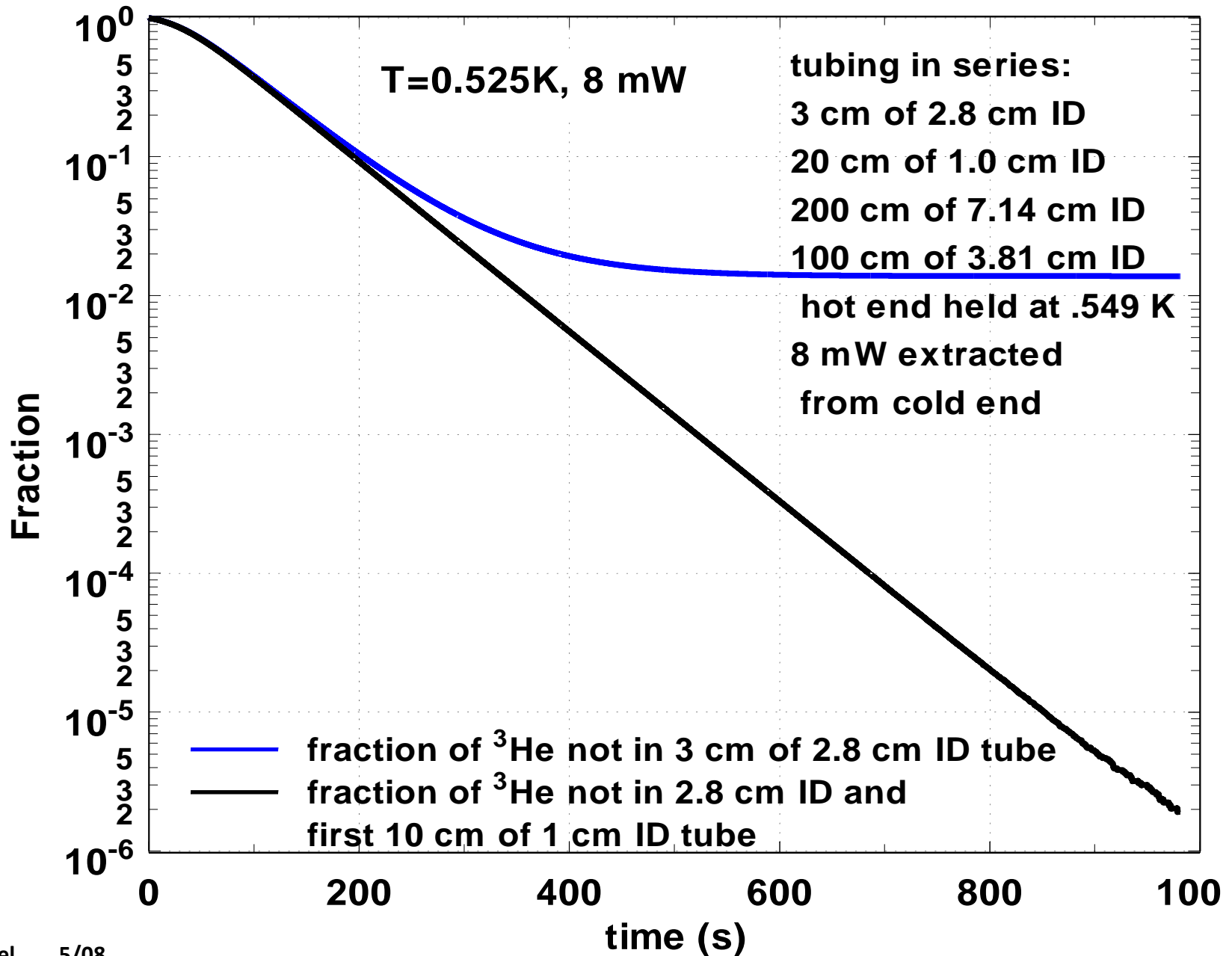
removal of liquid with high concentration of ^{3}He
and
replacement with pure ^{4}He

transfer liquid via
capillary, 0.05 cm, from
extraction volume to
evaporator
~60 J to evaporate 25 cm^3
recover gas for analysis

fill pure ^{4}He via capillary
from reservoir at 1.2 K
ΔH ~ .2 J
provision for filling system
initially?

heat transfer via helium
in capillaries is small

1 cm ID tube

extraction volume
~ 25 cm^3

evaporator
heat above 1 K